



NLC News -

Vol. 3, No. 6, June 2002

Director's Corner

David L. Burke

In its simplest form the linear collider challenge can be broken into two parts - transferring energy from the commercial AC power grid to beams of electrons and positrons, and making and colliding nanometer-sized beams to create luminosity. This issue of the News features articles by David Schultz on the 8-Pack that is the basic building block of the NLC X-band main linac, and by Tor Raubenheimer on R&D on techniques and technologies needed to create luminosity.

The 8-Pack is the integration of the key technologies of the NLC baseline rf system. The buzzwords to keep in mind are: "solid-state modulator," "PPM klystron," "over-moded planar SLED-II/DLDS pulse compression," and "high-gradient damped-detuned accelerator structures." These new technologies have been in development for the past 4-5 years - each to replace technologies presently in use at the NLCTA. The aim is to reduce the cost of the NLC and to double its reach in energy from 500 GeV, as demonstrated by the performance of the NLCTA in 1996, to 1 TeV.

The 8-Pack is as much a program as it is a project. The initial Phase-I goal is to establish the 600 MW x 400 ns pulse of X-band microwave energy needed to fill the unit length (5.4 meters) of high-gradient (70 MV/m) accelerator structures that make up the NLC main linac. This important milestone will demonstrate the soundness of the underlying technologies of the TeV rf system, and is the focus of the article by Schultz. Completion of the full 8-Pack and acceleration of beam in the NLCTA in the subsequent Phase-II will establish a firm base of experience on which to complete design and start construction of the NLC.

The SLC gave SLAC physicists a healthy dose of respect for the difficult task of creating and colliding precise small beams of electrons and positrons. And as Raubenheimer points out, "The NLC luminosity is *only a few* 10^4 times greater than that of the SLC." The NLC group has placed strong emphasis on investigation and demonstration of the beam dynamics, instrumentation, and control needed to create luminosity. Many of the challenges have been successfully addressed, and what remains is well identified. Tor summarizes where we stand in the second article in this edition of NLC News.

On a different note, the NLC Group bids farewell this month to Robbin Nixon. We've enjoyed five years of her enthusiasm and support, and wish her the best - it will be a difficult act to follow.

The 8-Pack Status - June 2002

David C. Schultz

If you have not been to End Station B recently you may not recognize the interior. The installation of the 8-Pack has been proceeding very rapidly and much of the infrastructure is in place. The massive support structure for the klystrons and modulator, which was designed and built by LLNL, is in place (Figure 1). The electronics racks have been mounted on their supports and connected to AC power (Figure 2). Cable trays are laid around the electronics racks (Figure 3), to the modulator/klystron stand, and up the NLCTA wall, and plumbing is being installed to provide cooling for the klystrons. The installation of the infrastructure is on schedule with the raised floor due to be put in place at the end of June, the phase 1 modulator due to be installed July 12th, and with the modulator ready to power klystrons at the end of August.



Fig. 1 - The Klystron/Modulator Support Stand, fabricated by LLNL, has been installed. The modulator oil tank in the foreground slides under the modulator support plate

The development of the solid-state modulator was challenged when it was found that the IGBTs used in it were susceptible to damage when a high voltage arc occurred. This has been addressed by switching to a different IGBT, and while the testing continues, indications now are that the new set-up will be adequate for 8-Pack phase 1 operations.

The development of the new high-power X-band PPM klystron at SLAC is more problematic. The first SLAC XP3 prototype exhibited an undesirable and unexpectedly strong oscillation in its output. This has caused a delay in the klystron program and has caused the 8-pack program to plan to use the XL4 X-band klystron to begin Phase 1. Four XL4s will be installed, each running at 50 MW and

1.6- μ s pulse length, and joined into two 100 MW feeds to the SLED system. A SLED compression of four and power amplification of three would then generate the 600-MW, 400-ns pulse as specified for 8-pack phase 1.

While this change is unfortunate, the switch to the XL4s does have advantages. The XL4 klystrons are the work-horse power source in use at NLCTA where they have run reliably for thousands of hours. Their reliability provides a stable base upon which the high-power testing of rf DLDS components can proceed. In addition, the XL4s are available and should be ready for installation as soon as the modulator is commissioned in place. The use of XL4 klystrons should advance the 8-pack Phase 1 schedule.

The XL4 has disadvantages as well. Principal among these is the solenoid on the klystron. For 8-Pack phase 1, the electromagnets require the temporary installation of four large power supplies near the klystrons in End Station B. The significant AC power required to operate the XL4 electromagnet is a major reason the XL4 is not a candidate for use on the NLC.

Fig. 2 - Electronics Racks in Place on Their Supports



For the DLDS system in phase 2 of the 8-pack project, it will be necessary for a successful PPM klystron to be developed. This puts great importance on solving the problems seen in the present tubes. It is anticipated that PPM klystrons will be available before they are needed, and these klystrons will be incorporated into the 8-pack system as soon as they are ready.

Overmoded SLED-II/DLDS high power rf pulse handling is a new approach that has been developed in the past few years. It uses a planar design in which the height of the components is used to lower fields and currents on the material surfaces. Laboratory tests done to date have verified the microwave properties of this basic

philosophy. Some of the details of the designs for phase 1 components are being fine tuned with a series of cold tests, which are underway. The cold testing results will be incorporated into the designs of the high power components prior to fabrication. This cold testing of the new parts was moved to early in the design cycle to ensure its success. A major goal of phase 1 of the 8-Pack is to test these components at high power to verify this basic technology - this will be an important milestone for the X-Band NLC.

Fig. 3 - The Klystron/Modulator Stand with the racks in the background and cable trays mounted



to the NLCTA Housing Wall

The LLRF modulators control phase and amplitude of the rf driving the klystron power amplifiers. Modulator performance has been validated in a test jig and the parts are here for assembly into the production system. The modulator is driven by the "Voltage step" (Vstep) module, in CAMAC, which rapidly switches between control levels established by slow digital to analog converters (DACs). This module has been prototyped, suitable transition times have been verified, and overshoot is under study. The Vstep gets its transition times from the Attenuator and Switch Control Unit(ASCU) which has been designed and has had critical circuitry bread-boarded. Rf monitoring depends upon two-stage downconversion. The first downconverter, which is local to the rf source, is under acceptance testing. The second downconversion is done by the (In-phase & Quadrature Amplitude (IQA) module. The IQA also provides a peak rf power signal to a VME ADC, and a fast interlock against fault conditions. The IQA module design is nearing completion.

Meanwhile, the controls backbone has been installed and checked out, and the high voltage power supply for the modulator has been installed. The advancement of all systems continues at full speed under an aggressive schedule.



Fig. 4 - The Klystron Mounting Boxes on the Klystron/Modulator Support Stand.



Fig. 5 - The High Voltage Power Supply for the Modulator is Installed

Luminosity R&D - Accomplishments and Future Plans

Tor Raubenheimer

A major strength of the NLC R&D program has been the broad attack on problems that can be conveniently classified as luminosity R&D.

Roughly one quarter of the NLC budget is directed towards these non-rf research areas. Over the last three years, work has included the electron photocathode and positron target, the damping rings, main linac beam dynamics and tuning, permanent magnets and electro-magnets, beam collimation, and the beam delivery system and interaction region. There have been many successful results:

- a photocathode that meets the NLC polarization and beam current requirements has been developed and tested in the E-158 experiment;
- the failure of the SLC positron target is understood and the e⁺ system has been redesigned accordingly;
- the ATF at KEK has achieved emittances less than a factor of two away from those required in the NLC and has studied many of the issues that will be relevant in the damping rings;
- the linac beam-based alignment procedures and limitations are well understood;
- collimator wakefields have been measured in a dedicated facility and an analytic theory was developed for rectangular collimators;
- a rigid block with 6-degrees-of-freedom has been stabilized;
- an integrated beam delivery system has been designed.

This has been excellent progress! Several of these topics can now be removed from the high priority list, including the beam collimators, the e⁻ photocathode and e⁺ target, and the static tuning of the linac emittances.

The next series of problems to be attacked are less obvious but very important. For the most part, these pertain to the stability of beams including those in the damping rings and in the linacs and beam delivery systems.

Why is the beam stability important? Beam-based alignment and tuning procedures downstream of the damping rings are essential to preserve the desired emittances; without these, it would be impossible to attain the small spot sizes necessary for the luminosity. However, the beam-based alignment and tuning procedures rely on stable beams. For example, the tuning procedures in the final focus are based on luminosity measurements. Although the direct luminosity loss due to the beam jitter is relatively small, the jitter will add noise and systematic errors to the luminosity measurements. A similar effect will arise in the main linacs where the beam jitter will degrade the emittance measurements and can have a significant impact on the Dispersion-Free steering. Some of the beam jitter effects can be subtracted from the measurements, as was attempted at the SLC, however in practice it is difficult to make enormous reductions with this approach.

The primary sources of jitter are instabilities in the damping rings, vibration of the many linac and beam delivery quadrupoles, and vibration of the final doublet. The typical tolerance on most of the

quadrupoles downstream of the damping rings is roughly 10 nanometers, which is comfortably above the natural vibration of the ground. However, it must be ensured that all additional sources of noise do not create significantly larger motions. Potential noise sources include the cooling systems, conventional facilities, rf power sources, and resonances in the support structures. The effect of coolant flow in the magnets has been measured to be a few nanometers; however, the effect of coolant flow in the adjacent accelerator structures has been measured to be a few hundred nanometers. At this time, it is not known whether the coupling of the structures to the quadrupoles or the structural resonances of the supports will lead to additional vibration. Because there are roughly two thousand quadrupole magnets, it is important to develop a low cost solution for these vibration issues and for this reason, a linac girder assembly prototype will be tested.

In the interaction region, the final quadrupoles are mounted on a cantilevered support that extends part way into the detector. Here, the vibration tolerance is a fraction of the colliding beam size, i.e., subnanometer. It will be extremely difficult to attain such small motion in this environment; thus, methods of actively stabilizing these magnets are under investigation. Two approaches are being pursued: an 'optical anchor,' which has been developed at the University of British Columbia and SLAC, could be used to attach the magnets rigidly to bedrock material under the detector and, an inertial system, that has been developed at SLAC. Initial tests of these systems have demonstrated their feasibility and it is now time to apply them to an engineered mock-up of an interaction region with model magnets, masking etc.

Finally, all of the downstream systems rely on the stability of the beam in the rings, and the accelerator physics issues in the rings are probably the most complicated in the entire NLC. As is well known from the operation of SLC, "the damping rings are the source of all evil." Thus, although excellent progress has been made on the NLC damping ring design and in the operation of the KEK ATF, work is still needed on the performance of the damping rings. These three areas will receive the bulk of the luminosity R&D funding over the next few years.

A Farewell and Godspeed to Robbin

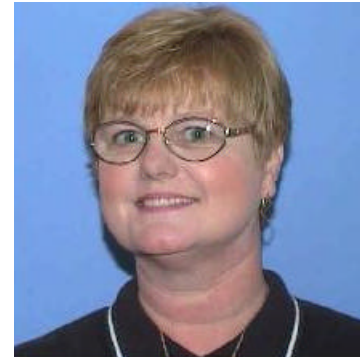
After 14 years of devoted service to SLAC, the last 5 at the Next Linear Collider Program Office, our senior administrator, Robbin Nixon, is leaving us.

Most members of the Machine Advisory Committee, the International Study Groups and the collaboration know Robbin well as that cheery and efficient person who gets things done – meeting organization, those awesome notebooks, hotel room blocks, social functions, you name it. All of this is, of course, in addition to keeping the NLC staff in line, monitoring personnel activities and budgets, travel, our NLC office buildings, supervising other administrative staff and all the myriad other things an senior admin at SLAC has to do.

Robbin's husband of thirty-plus years recently took a position in Reno, NV and Robbin originally planned 6 months to a year of a commuting marriage. After a whole four days, she said "enough," and with great efficiency put their house on the market, got it sold in one weekend, and is now ready to move to Reno. While her first months there will be on vacation from SLAC, she effectively leaves us on Friday, 14 June.

Robbin's loss will leave a hole in our organization of energy and spirit. I think many of us, working at SLAC's NLC program and at PEP II before that, think of her as the project's heart and we will find the NLC office, without her infectious spirit and laughter, a much drearier place with her absence.

Nonetheless, we fully understand her reasons for leaving, and all of us wish her every happiness and fulfillment in her new life in Reno.



The 'Official' Robbin



Robbin at the 2001 NLC Holiday Party



The 'Real' Robbin

E-158 Success Story

The following table compares E158 beam parameters with those for the NLC. E158 has achieved outstanding results in a recent 6-week data collection and analysis period.

Sometime soon we hope to publish a full story about these, but they represent significant achievement.

Comparison of E158 and NLC Beam Parameters

Parameter	E158	NLC-500
Charge/Train	6×10^{11} (*)	14.3×10^{11}
Train Length	270ns	260ns
Bunch spacing	0.3ns	1.4ns
Rep Rate	120Hz	120Hz
Beam Energy	15 GeV	250 GeV
e ⁻ Polarization	80%	80%

*polarized source has 25% overhead in available charge

NEW! Gradient-doped strained GaAs photocathode
(developed for NLC)

Recent Linear Collider Publications

If you would like to have an NLC-related paper listed, please send information to amlarsen@slac.stanford.edu

I. Linear Collider Collaboration Notes

http://www-project.slac.stanford.edu/lc/ilc/TechNotes/LCCNotes/lcc_notes_index.htm

LCC-0018, Rev. B, G.V. Stupakov, "Correct Account of RF Deflections in Linac Acceleration," Rev. B, June 2002.

Calendar of Upcoming Events

Conferences of Interest

ISG-8, the Eighth NLC/JLC Study Groups, June 24-27 at SLAC. http://www-project.slac.stanford.edu/lc/ilc/ISG_Meetings/ISG8/nlcisg8.htm

Santa Cruz Linear Collider Retreat
27-29 Jun 2002, Santa Cruz, California; <http://scipp.ucsc.edu/LC/>

31st International Conference on High Energy Physics (ICHEP 2002), 24-31 Jul 2002, Amsterdam, The Netherlands, <http://www.ichep02.nl/>

Linac 2002, Gyeongju, Korea - August 19 - 23, 2002. <http://linac2002.postech.ac.kr/linac-ju/index.html>

International Workshop on Linear Colliders (LCWS 2002), 26-30 Aug 2002, Jeju Island, Korea, <http://lcws2002.korea.ac.kr/>

IEEE 2002 Nuclear Science Symposium (NSS) and Medical Imaging Conference (MIC) and Symposium on Nuclear Power Systems 10-16 Nov 2002, Norfolk, Virginia, <http://www.nss-mic.org>

Particle Accelerator Conference (2003 PAC)
Portland, OR, 12-16 May 2003;
Siemann@slac.stanford.edu

Quips and Quotes -- with thanks to Ken Dawson of TRIUMF

Full House

"Science is a first-rate piece of furniture for a man's upper chamber, if he has common sense on the ground floor."

Oliver Wendell Holmes

Sisyphean Task

"Science in the very act of solving problems, creates more of them."

Abraham Flexner

Why??

"Curiosity is one of the certain and permanent characteristics of a vigorous mind."

Samuel Johnson

Out of Toyland

"The electron - up to that time largely the plaything of the scientist - had clearly entered the field as a patent agent in the supplying of man's commercial and industrial needs."

Robert Millikan (on the achievement of New York to San Francisco phone calls)

Besieged

"...so why do we stand here confronted by insurmountable opportunities?"

Walt Kelly (Pogo)

Clear Vision

"Science is a long history of learning how not to fool ourselves."

Richard Feynman